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by

Dennis E. Teeguarden

March, 1969

School of Forestry and Conservation, University of California
Berkeley, California

A report to the U.S. Department of Interior, Bureau of Land Management, prepared under Research Contract No. 14-11-001-3872.

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INTRODUCTION

This report is the second in a series of studies designed to provide methods for rating Douglas-fir reforestation opportunities on lands administered by the Bureau of Land Management in Western Oregon. The first report developed a method of analysis and gave cost-effectiveness criteria which could be used for ranking reforestation projects in the Bureau's Roseburg District according to their desirability as investments.[1] The present report gives, in charts and tables, similar criteria for use in the Salem District. The criteria may be used to establish work priorities when capital is limiting and the planning problem is to select regeneration method and projects which will maximize the economic effectiveness of investing a predetermined, fixed amount of money in new plantations.

The analytical method and underlying philosophy are discussed in detail elsewhere.[2] For brevity, only a summary of the method, computational procedure, and data used are given below. In particular, users may wish to consult the earlier report with reference to such matters as choice of a cost-effectiveness criterion, basis for estimating value yields, procedures followed in estimating risk factors, and results of sensitivity analyses.

It is emphasized that the criteria given in this report are applicable only in the Salem District. For other areas some of the underlying data will have to be revised and the criteria recomputed.

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[1] See Teeguarden, Dennis E. 1969. Economic guides for Douglas-fir Re-forestation in Southwestern Oregon. U.S. Dept. Interior Technical Publication No. (2). In press. Washington, D.C.

[2] Ibid.

REFORESTATION ACTIVITIES EVALUATED

Four kinds of management practices are evaluated in this report: (1) planting recently cutover, essentially bare land; (2) aerial seeding recently cutover, essentially bare land; (3) planting unstocked land or other heavily vegetated land which resulted from old logging operations, fires, or plantation failures; and (4) interplantings in substocked plantations. With the assistance of District reforestation personnel, these practices were further subdivided to reflect various combinations of treatments or factors influencing costs. In all, 15 treatment classes were defined (see Table 1). Seven classes consider first plantings; two classes consider first seedings; and three classes consider interplantings.

The contribution which such practices as those noted make to the Bureau's management goal depends upon numerous factors besides costs. Important are: (1) prospective yields from new plantations; and (2) the probability of regeneration failure. For example, a Douglas-fir site II potentially may yield more than twice as much commercial timber as a site IV. And experience indicates that a greater proportion of plantings will fail on site IV than on site II. To reflect such factors in computing cost-effectiveness criteria, 18 combinations of elements influencing site productivity and risk of regeneration failure were recognized. Differences in prospective yields were considered by defining three Douglas-fir site qualities: site II(170), site III(140), and site IV(110). Risk of regeneration failure was considered by recognizing the influence of site quality, aspect, exposure of mineral soil, and location in the district -- whether in the Cascade Range or in the Coast Range. Two aspects, north and south, were defined as follows:

Table 1. -- Estimated Douglas-fir reforestation costs, by reforestation-treatment classes, Salem District, 1968

Reforestation-treatment class	Treatment cost dollars per acre
Planting -- bare land, class A	35.90
Planting -- bare land, class B	32.90
Seeding -- bare land, class A and B	10.00
Planting -- bare land, class A, posttreatment chemical brush control	41.10
Planting -- bare land, class B, posttreatment brush chemical control	38.10
Seeding -- bare land, class A and B, posttreatment chemical brush control	15.20
Planting -- bare land, class A, concurrent chemical grass control	49.90
Planting -- bare land, class B, concurrent chemical grass control	46.90
Planting -- brushland, class A, chemical site preparation	41.90
Planting -- brushland, class B, chemical site preparation	38.90
Planting -- brushland, class A, chemical site preparation and postplanting brush control	47.10
Planting -- brushland, class B, chemical site preparation and postplanting brush control	44.10
Interplanting -- substocked plantations	24.00
Interplanting -- substocked plantations, concurrent chemical grass control	38.00
Interplanting -- substocked plantation, concurrent chemical brush control	30.00

True bearing	Aspect
0-120	north
121-299	south
300-360	north

Three degrees of mineral soil exposure were defined as follows:

Good -- 70-100 percent exposure of mineral soil
Fair -- 30-69 " " " " "
Poor -- 0-29 " " " " "

Combining three site qualities, two aspects, and three degrees of mineral soil exposure gave 18 site classes. Combining site classes with treatment classes gave 216 treatment-site classes (Table 6) for the Cascade areas of the district and 216 classes for the coast areas. Each class in effect represents a project alternative. To use the guides presented in this report, all land up for consideration for treatment in a given planning year is first classified according to treatment-site class. Then the criteria given in Tables 6 and 7 or in the charts may be used to rate the different classes along a scale of good to poor in terms of their relative desirability as investments. For tracts which may be either planted or seeded, a procedure is provided which enables the planner to choose the best method of regeneration. Steps to follow in using the guides are discussed further below.

COST-EFFECTIVENESS CRITERIA

The criteria given in this report are based on analyses of prospective costs and benefits of artificially establishing Douglas-fir plantations. Details of procedure are somewhat complex, but the general method is relatively simple. It consisted of: (1) defining the reforestation alternatives to be analyzed, as discussed above; (2) gathering basic data on treatment costs,

prospective yields, probabilities of regeneration success for each alternative means of obtaining regeneration (planting, seeding, and natural), and stumpage values; and finally (3) converting the basic data to cost-effectiveness indices. In this report, the indices are expressed as dollar-return-per-dollar invested.

Treatment-costs

Estimated total treatment costs per acre for each of the 15 treatment classes are shown in Table 1. These costs refer to modal projects, i.e., to tracts of land with average site conditions that influence treatment costs. Cost of some projects may differ from the modal cost estimates; where this is the case, the user may want to recompute the criteria reported in Tables 6 and 7.

Treatment cost estimates were built up from separate estimates of each cost element. For example, planting cost was estimated on the basis of the contract rate for planting, cost of seedlings purchased from the state nursery, variable administrative cost, and the cost of special measures such as site preparation or postplanting application of silvicides. Basic cost data are shown in Table 2; these were derived from data obtained from District Office records and from estimates of reforestation personnel.

Wood yields

Wood yield estimates for first plantings or seedings are shown in Table 3. It was assumed in deriving these estimates that Douglas-fir plantations will be thinned at relatively early age until rotation age. To be consistent with other assumptions of the study, these estimates were prepared using a 3 percent rate of return criterion to determine optimum stocking levels and rotation age. Under the 3 percent criterion, the calculated rotations were 70, 80, and 90 years for sites II, III, and IV, respectively. As noted below, all yield estimates were reduced in order to reflect risk of plantation failure

Table 2. -- Estimated Douglas-fir reforestation costs, by cost item, Salem District, Western Oregon[1/]

Cost item	Cost, dollars per acre
Planting (8 x 8 spacing, 680 trees per acre):	
50-74 percent of area plantable (Class A)	24.00
75-100 percent of area plantable (Class B)	21.00
Aerial seeding @ 0.75 lbs. per acre	0.63
Aerial application of Atrazine (5 lbs. per acre):	
Chemical (@ $2.10/lb.)	10.50
Application	3.00
Administration	0.50
Aerial application of 2-45-T OS (1 lb. acid equivalent per acre):	
Chemical (@ $2.50/lb.)	2.50
Application	3.00
Administration	0.50
Douglas-fir trees, (2-0 treated stock @ $14.40 per thousand trees):	
680 trees per acre	9.80
500 trees per acre	7.20
Douglas-fir seed (0.75 lb. per acre @ $11.70 per pound)	8.77
Variable administrative costs (contract development, area layout, supervision):	
Seeding	0.55
Planting	2.10

[1/] Based on Bureau of Land management cost experience, Salem District, Western Oregon, 1966-69.

Table 3. -- Assumed yields of Douglas-fir under a thinning regime, by decade or stand age, and by site class

(In board feet per acre, Scribner rule)

Stand Age	Site class		
	170	140	110
	First plantings or seedings[1/]		
30	2,200	--	--
40	4,500	800	--
50	8,500	5,000	700
60	13,500	7,200	3,000
70	41,500	10,200	3,350
80	--	32,000	6,900
90	--	--	17,000
	Interplantings		
30	2,200	--	--
40	4,500	800	--
50	8,500	5,000	700
60	13,500	7,200	3,000
70	--	10,200	3,350
80	--	--	6,900

[1/] Derived from growth model relationships reported in Timber Trends in Western Oregon and Western Washington, U.S. Forest Service Research Paper PNW-5.

and to account for prospective yields from natural regeneration which are anticipated to occur in the absense of special efforts to secure stocking artificially.

The yield credited to interplanting in substocked plantations was taken as the yield of a fully-stocked plantation (680 trees per acre) less yield anticipated from substocked stands. A substocked plantation with 50-100 trees per acre was selected as the benchmark for estimating returns to interplanting. It was assumed that in the absence of interplanting the stand will not provide an opportunity for thinning and the final harvest yield is approximately equivalent to 72 percent of normal yields at rotation age on site II; to 70 percent on site III; and to 65 percent on site IV. The resulting yield estimates are given in Table 3.

In the case of planting brush land, it was assumed that there would be no yield in the absence of special efforts to establish regeneration artificially. The yields credited to such treatments are those given in Table 3 for first plantings, adjusted for risk of failure.

Probabilities of regeneration success

Probabilities of regeneration success for the various site classes and regeneration methods are given in Table 4. The probabilities were used to weight value yields in order to account for this one element of risk. The estimates are based on the collective judgement of a panel of 10 foresters who were engaged in reforestation work in Western Oregon. Included were five members of the Salem District staff. The data were obtained in a decision-game which was conducted in the Salem District in February, 1968. Separate estimates were obtained for the eastside (Cascade Range) and westside (Coast-Range) areas of the district. The technique used is described in U.S. Department [illegible] the prospective [illegible] from [illegible]

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Table 4. -- Estimated probability of regeneration success, Salem District, Western Oregon

EASTSIDE (Cascade Range)

(in percent of 100 trials)

Regeneration method	Site II		Site III		Site IV	
	North aspect	South aspect	North aspect	South aspect	North aspect	South aspect
	70 percent or more exposure of mineral soil					
Natural	58	27	48	23	25	12
Aerial seeding	90	64	79	56	70	44
Planting	98	77	94	80	83	79
	30-69 percent exposure of mineral soil					
Natural	47	24	32	20	20	10
Aerial seeding	85	54	72	50	65	35
Planting	94	87	88	82	84	77
	0-29 percent exposure of mineral soil					
Natural	28	20	20	14	15	8
Aerial seeding	80	45	67	30	56	25
Planting	90	85	86	80	83	68

WESTSIDE (Coast Range)

	70 percent or more exposure of mineral soil					
Natural	25	12	21	10	11	5
Aerial seeding	70	50	61	44	54	34
Planting	90	85	86	78	76	72
	30-69 percent exposure of mineral soil					
Natural	22	10	15	8	9	4
Aerial seeding	65	45	55	41	49	29
Planting	89	77	85	70	81	65
	0-29 percent exposure of mineral soil					
Natural	17	8	12	5	9	3
Aerial seeding	60	35	40	20	34	17
Planting	88	64	80	60	77	51

of Interior Technical Report No. ( ).

Stumpage values

To compare treatment costs and wood yield response on a common basis the latter were converted to dollar values. This was done by applying the stumpage value schedule shown in Table 5 to the yield schedules developed in Table 3.

A basic stumpage value of $36.00 per thousand board feet was used as a basis for computing the dollar value of wood yields. It was applied to trees averaging about 26 inches d.b.h., then adjusted downward to reflect higher conversion cost differentials for smaller trees.

The basic stumpage value assumed in this study is lower than current prices being paid for old-growth Douglas-fir stumpage in Western Oregon. However, it appears fairly consistent with long run trends in stumpage values. More important, analysis suggests that the Douglas-fir reforestation practices which are rated in this study are not affected by the stumpage price level assumed in computing the dollar-return criteria.[3] Rankings may, on the other hand, be affected by the value differentials assumed in Table 5. A smaller differential, for example, will tend to favor interplantings because all the yield attributed to this practice occurs in early thinnings. In contrast, a larger differential tends to make interplantings relatively less attractive compared to first treatments on bare land or brushlands.

Interest rate

To compare future value yields with initial treatment cost on a comparable

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[3] See Teeguarden, op. cit.

Table 5. -- Assumed stumpage values for second-growth Douglas-fir, by stand age and site class

(in dollars per thousand board feet, Scribner Rule)

Stand age	Site II (170)	Site III (140)	Site IV (110)
30	0.40	--	--
40	11.90	0.40	--
50	24.00	11.90	0.40
60	29.30	20.10	11.90
70	36.00	25.60	20.10
80	--	35.30	24.00
90	--	--	31.40

basis, the former were expressed in terms of their present value equivalents using the formula discussed below. A 3 percent discount rate was chosen for this purpose.

Computational Model

The basic economic model employed to compute dollar-return estimates for the various treatment-site classes is a variant of the benefit-cost ratio, long used to evaluate federal water development projects.[4/] In equation form, it is expressed symbolically as follows:

[4/] All computations were made on a CDC 6400 computer using a program written in Fortran IV. A program listing will be made available in a subsequent report.

$$D/C = \frac{1}{C}\left[\frac{S_{30}Y_{30}}{(1.0p)^{30}} + \frac{S_{40}Y_{40}}{(1.0p)^{40}} + \cdots + \frac{S_{90}Y_{90}}{(1.0p)^{90}}\right](P^{*} - P_{n})$$

Where:

D/C = present value dollar-return-per-dollar invested

C = initial treatment cost, dollars per acre (Table 1)

S = stumpage value, dollars per thousand bd. ft., by stand age through final rotation (Table 5)

Y = wood yields, in thousand board feet per acre, for each stand age through final rotation (Table 3)

p = rate of interest

P^{*} = probability of regeneration success with planting or seeding for a given treatment-site class (Table 4)

P_n = probability of natural regeneration success for a given site class (Table 4)

The factor $(P^{*} - P_n)$ requires clarification. In this study it was assumed that wood yields from established plantations which meet the Bureau's minimum stocking standards will be the same regardless of regeneration method. However, the probability of attaining that standard is considered to vary among the various treatment-site alternatives as noted above. To account for this one element of risk, the expected value yield is computed by multiplying value yields by the probability that a given treatment will result in a successful plantation. The effect of this calculation is to give higher ratings to the lower-risk treatment-site classes, other factors equal. A final step is to subtract from expected value yield the prospective value of natural regeneration which is expected regardless of whether attempts are made to establish

trees artificially. The result is the additional expected value yield which can be attributed to artificial reforestation expenditures. The effect of this calculation is to give relatively low ratings to treatment-site classes where the chance of natural regeneration occurring is comparatively large, other factors equal. In the equation givenabove, the term $(P^* - P_n)$ simultaneously adjusts value yield estimates for risk of artificial regeneration failure and for the expected yields from natural regeneration which may be realized in any event.[5/]

The criteria

Cost-effectiveness criteria are presented in two formats: tables and charts. Tables 6 and 7 show present value dollar-return-per-dollar invested for each of the 15 treatments and 18 site classes. Two sets of criteria are provided; one for the eastside (Cascade section) part of the district and one for the westside (Coast section). Treatment costs assumptions used in deriving these dollar-return criteria are given in Table 1.

Figures 1 - 20 show the relationship between dollar-return-per-dollar-invested for different treatment cost levels for the various treatment-site situations examined. The curves were derived by solving the formula above for different values of C with the other factors held constant. Given the treatment cost assumptions in Table 1, an estimated dollar-return-per-dollar invested can be determined from the appropriate chart. This is done by reading from the chart the dollar return corresponding to treatment cost. The dollar-return determined from the chart will correspond to the one shown in Tables 6 and 7. However, the charts provide additional information. They

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[5/] For a more complete explanation of the procedure, see U.S.D.I. Tech. Bull. No. (2).

can be used to examine the sensitivity of dollar-return estimates to treatment cost assumptions which underlie them. And the charts can be used to make dollar-return estimates for projects with treatment-costs which differ from the modal cost estimates given in Table 1, so long as the other assumptions used in estimating dollar-return are applicable to the situation.

USING THE GUIDES

Tables 6 and 7 or Figures 1 - 20 may be used as guides to establishing reforestation work priorities and to choosing regeneration method by following the following steps:

1. From rehabilitation work records determine the following for each tract of land to be considered:

   Location -- whether in Cascade or Coastal section of the district.

   Site quality -- whether II, III, or IV

   Land class: 50-74 percent of area plantable, class A
   75-100 percent of area plantable, class B

   Aspect -- whether north or south

   Seedbed condition -- good exposure (70-100 percent), fair exposure (30-69 percent), or poor exposure (0-29 percent) of bare mineral soil

   Treatment or treatment alternatives to be considered (as defined in Table 1).

2. From Tables 6 or 7 (or Figures) obtain an estimate of dollar-return-per-dollar invested. If using a table, enter the row corresponding to the location of the tract (west or east), seedbed condition,

Table 6. -- Cost-effectiveness indexes for Douglas-fir reforestation investment opportunities, eastside Salem District

Treatment-class	Dollar return per dollar invested					
	Site-aspect class					
	II-N	II-S	III-N	III-S	IV-N	IV-S
	poor exposure of mineral soil					
Planting -- bare land, class A	5.5	5.8	3.3	3.3	1.3	1.1
Planting -- bare land, class B	6.0	6.3	3.6	3.6	1.4	1.2
Seeding - bare land	16.6	8.0	8.4	2.8	2.8	1.2
Planting -- bare land, class A, posttreatment chemical brush control	4.8	5.0	2.9	2.9	1.1	1.0
Planting -- bare land, class B, posttreatment chemical brush control	5.2	5.4	3.1	3.1	1.2	1.1
Seeding -- bare land, posttreatment chemical brush control	11.0	5.2	5.6	1.9	1.9	0.8
Planting -- bare land, class A, concurrent chemical grass control	4.0	4.1	2.3	2.3	0.9	0.8
Planting -- bare land, class B, concurrent chemical grass control	4.2	4.4	2.5	2.5	1.0	.9
Interplanting -- substocked plantations	4.9	4.6	2.6	2.4	1.1	0.9
Interplanting -- substocked plantations, concurrent chemical grass control	3.1	2.9	1.6	1.5	0.6	0.5
Interplanting -- substocked plantations, concurrent chemical brush control	3.9	3.7	2.1	1.9	0.8	0.7

Table 6. -- (Continued)

Treatment-class	Dollar return per dollar invested					
	Site-aspect class					
	II-N	II-S	III-N	III-S	IV-N	IV-S
	fair exposure of mineral soil					
Planting -- bare land, class A	4.2	5.4	2.7	3.1	1.2	1.2
Planting -- bare land, class B	4.6	6.0	3.0	3.4	1.3	1.3
Seeding - bare land	12.0	9.2	7.0	5.2	3.0	2.7
Planting -- bare land, class A, posttreatment chemical brush control	3.7	4.8	2.3	2.7	1.0	1.0
Planting -- bare land, class B, posttreatment chemical brush control	4.0	5.2	2.5	2.9	1.1	1.1
Seeding -- bare land, posttreatment chemical brush control	8.0	6.2	4.8	3.6	2.2	1.2
Planting -- bare land, class A, concurrent chemical grass control	3.0	4.0	1.9	2.2	0.8	0.8
Planting -- bare land, class B, concurrent chemical grass control	3.2	4.2	2.0	2.3	0.9	0.9
Interplanting -- substocked plantations	5.1	4.7	2.6	2.5	1.1	1.1
Interplanting -- substocked plantations, concurrent chemical grass control	3.3	3.0	1.6	1.5	0.7	0.7
Interplanting -- substocked plantations, concurrent chemical brush control	4.1	3.8	2.1	2.0	0.9	0.9

Table 6. -- (Continued)

Treatment-class	Dollar return per dollar invested					
	Site-aspect class					
	II-N	II-S	III-N	III-S	IV-N	IV-S
	Good exposure of mineral soil					
Planting -- bare land, class A	3.6	4.4	2.2	2.8	1.1	1.2
Planting -- bare land, class B	3.9	4.8	2.5	3.0	1.2	1.4
Seeding -- bare land	10.2	11.8	5.4	5.8	3.0	2.1
Planting -- bare land, class A, posttreatment chemical brush control	3.1	3.8	2.0	2.4	0.9	1.1
Planting -- bare land, class B, posttreatment chemical brush control	3.3	4.1	2.1	2.6	1.0	1.2
Seeding -- bare land, posttreatment chemical brush control	6.8	7.8	3.7	4.0	1.4	2.0
Planting -- bare land, class A, concurrent chemical grass control	2.5	3.1	1.6	2.0	0.7	0.9
Planting -- bare land, class B, concurrent chemical grass control	2.7	3.3	1.7	2.1	0.8	1.0
Planting -- brushland, class A, chemical site preparation	7.4	5.8	4.0	3.2	1.2	1.0
Planting -- brushland, class B, chemical site preparation	7.9	6.2	4.2	3.6	1.4	1.0
Planting -- brushland, class A, chemical site preparation and postplanting brush control	6.6	5.2	3.6	3.0	1.1	0.9
Planting -- brushland, class B, chemical site preparation and postplanting brush control	7.0	5.5	3.8	3.1	1.2	1.0
Interplanting -- substocked plantations	5.3	4.2	2.8	2.4	1.0	1.0
Interplanting -- substocked plantations, concurrent chemical grass control	4.2	3.3	2.3	1.9	0.8	0.8
Interplanting -- substocked plantations, concurrent chemical brush control	3.4	2.6	1.8	1.5	0.6	0.6

Table 7. -- Cost-effectiveness indexes for Douglas-fir reforestation investment opportunities, westside Salem District

Dollar return per dollar invested

Treatment-class	Site-aspect class					
	II-N	II-S	III-N	III-S	IV-N	IV-S
	poor exposure of mineral soil					
Planting -- bare land, class A	6.3	4.9	3.4	2.7	1.3	0.8
Planting -- bare land, class B	6.8	5.4	3.6	2.9	1.4	0.9
Seeding -- bare land	13.4	8.6	4.8	2.6	1.6	1.0
Planting -- bare land, class A, posttreatment chemical brush control	5.5	4.3	2.9	2.4	1.1	0.7
Planting -- bare land, class B, posttreatment chemical brush control	5.9	4.6	3.2	2.6	1.2	0.8
Seeding -- bare land, posttreatment chemical brush control	9.0	5.7	3.4	1.8	1.1	0.6
Planting -- bare land, class A, concurrent chemical grass control	4.5	3.5	2.4	1.9	0.9	0.6
Planting -- bare land, class B, concurrent chemical grass control	4.8	3.7	2.6	2.1	1.0	0.6
Interplanting -- substocked plantations	4.7	5.4	2.4	1.8	1.0	0.6
Interplanting -- substocked plantations, concurrent chemical grass control	3.0	2.2	1.5	1.1	0.6	0.4
Interplanting -- substocked plantations, concurrent chemical brush control	3.8	2.8	1.9	1.4	0.8	0.5

Table 7. -- (Continued)

Dollar return per dollar invested

Treatment-class	Site-aspect class					
	II-N	II-S	III-N	III-S	IV-N	IV-S
	fair exposure of mineral soil					
Planting -- bare land, class A	5.9	5.9	3.5	3.1	1.4	1.1
Planting -- bare land, class B	6.5	6.5	3.8	3.3	1.5	1.2
Seeding -- bare land	13.7	11.0	7.0	5.9	2.7	1.6
Planting -- bare land, class A, posttreatment chemical brush control	5.2	5.2	3.0	2.7	1.2	1.0
Planting -- bare land, class B, posttreatment chemical brush control	5.6	5.6	3.3	2.9	1.3	1.0
Seeding -- bare land, posttreatment chemical brush control	9.1	7.4	4.6	3.8	1.8	1.1
Planting -- bare land, class A, concurrent chemical grass control	4.3	4.3	2.5	2.2	1.0	0.8
Planting -- bare land, class B, concurrent chemical grass control	4.6	4.6	2.6	2.3	1.0	0.8
Interplanting -- substocked plantations	4.8	4.2	2.5	2.1	1.0	0.8
Interplanting -- substocked plantations, concurrent chemical grass control	3.1	2.6	1.6	1.3	0.6	0.5
Interplanting -- substocked plantations, concurrent chemical brush control	3.9	3.3	2.0	1.7	0.8	0.6

Table 7. -- (Continued)

Dollar return per dollar invested

Treatment-class	Site-aspect class					
	II-N	II-S	III-N	III-S	IV-N	IV-S
	good exposure of mineral soil					
Planting -- bare land, class A	5.7	6.4	3.2	3.3	1.2	1.2
Planting -- bare land, class B	6.2	7.0	3.5	3.6	1.3	1.3
Seeding -- bare land	14.2	12.0	7.0	6.0	2.9	1.9
Planting -- bare land, class A, posttreatment chemical brush control	5.1	5.6	2.8	2.9	1.0	1.0
Planting -- bare land, class B, posttreatment chemical brush control	5.4	6.1	3.0	3.1	1.1	1.1
Seeding -- bare land, posttreatment chemical brush control	9.4	8.0	4.7	4.0	1.9	1.3
Planting -- bare land, class A, concurrent chemical grass control	4.1	4.6	2.3	2.4	0.9	0.9
Planting -- bare land, class B, concurrent chemical grass control	4.4	4.9	2.4	2.5	0.9	0.9
Planting -- brushland, class A, chemical site preparation	6.8	6.4	3.6	3.2	1.2	0.9
Planting -- brushland, class B, chemical site preparation	7.3	6.8	3.9	3.4	1.3	1.0
Planting -- brushland, class A, chemical site preparation and postplanting brush control	6.1	5.7	3.2	2.8	1.0	0.8
Planting -- brushland, class B, chemical site preparation and postplanting brush control	6.4	6.1	3.4	3.0	1.1	0.9
Interplanting -- substocked plantations	4.9	4.6	2.6	2.4	1.0	1.0
Interplanting -- substocked plantations, concurrent chemical grass control	3.1	3.0	1.6	1.4	0.6	0.6
Interplanting -- substocked plantations, concurrent chemical brush control	3.9	3.7	2.0	1.9	0.8	0.8

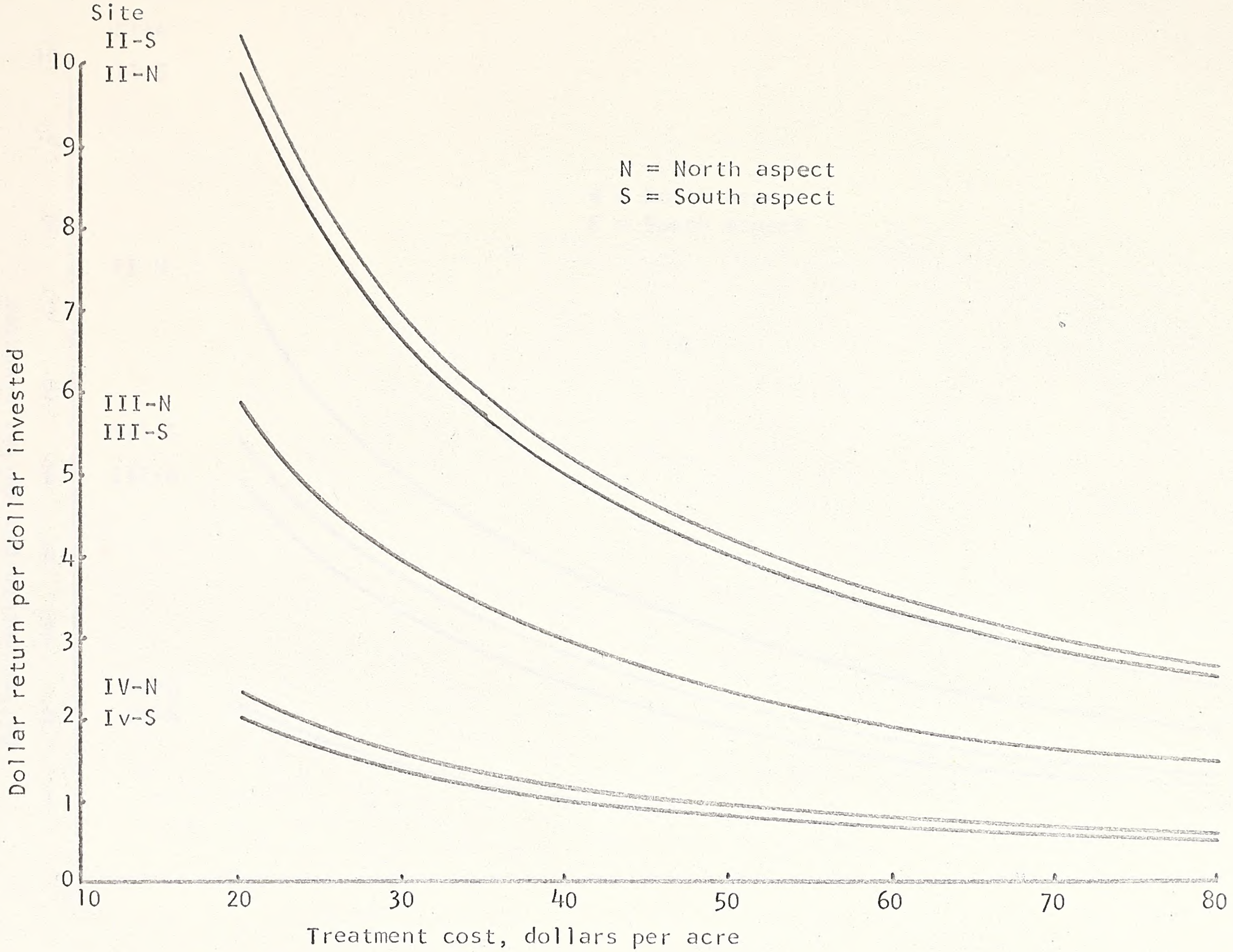

Figure 1. Dollar return per dollar invested. Planting east side land with poor exposure mineral soil (0-29 percent)

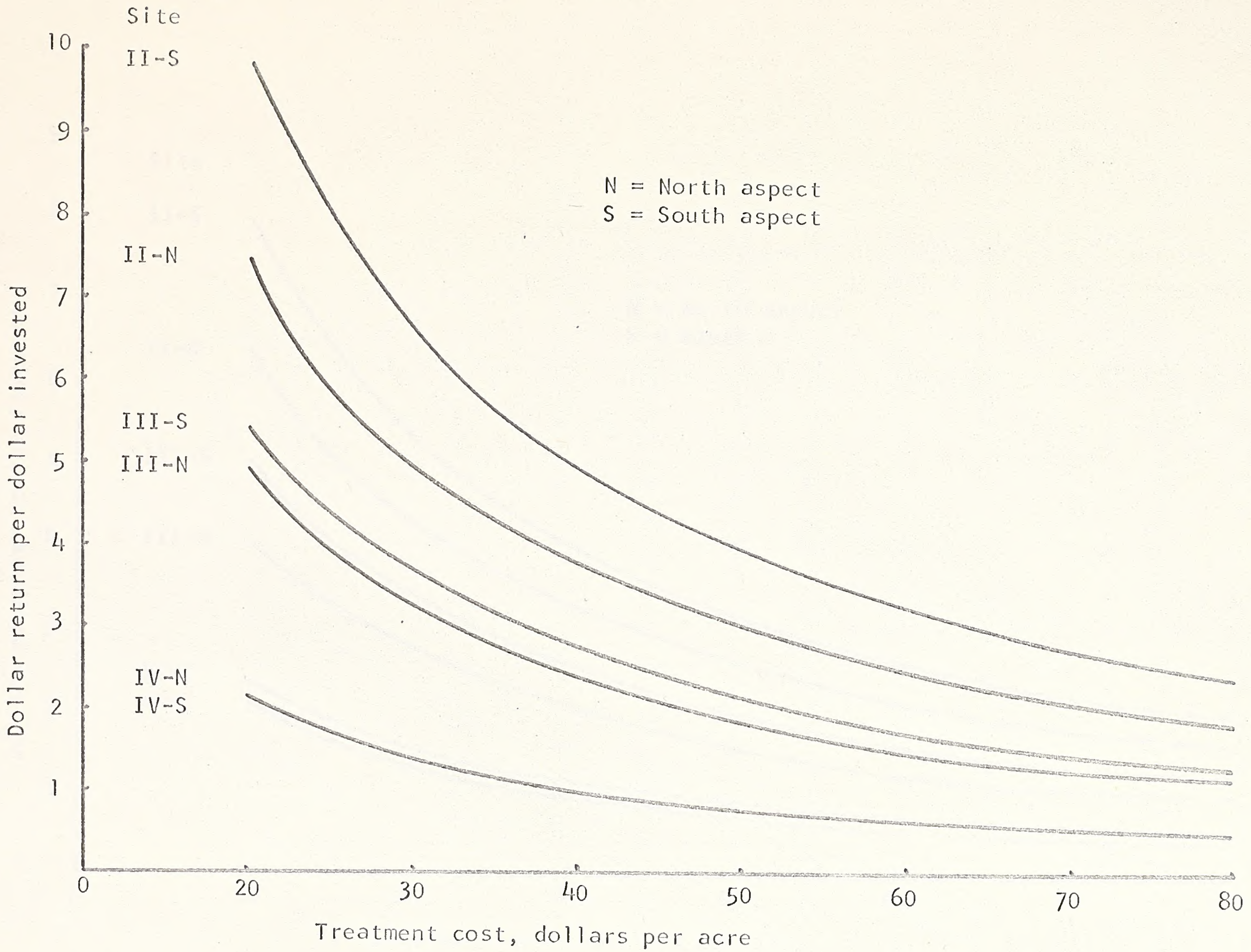

Figure 2. Dollar return per dollar invested. Planting east side land with fair exposure mineral soil (30-69 percent)

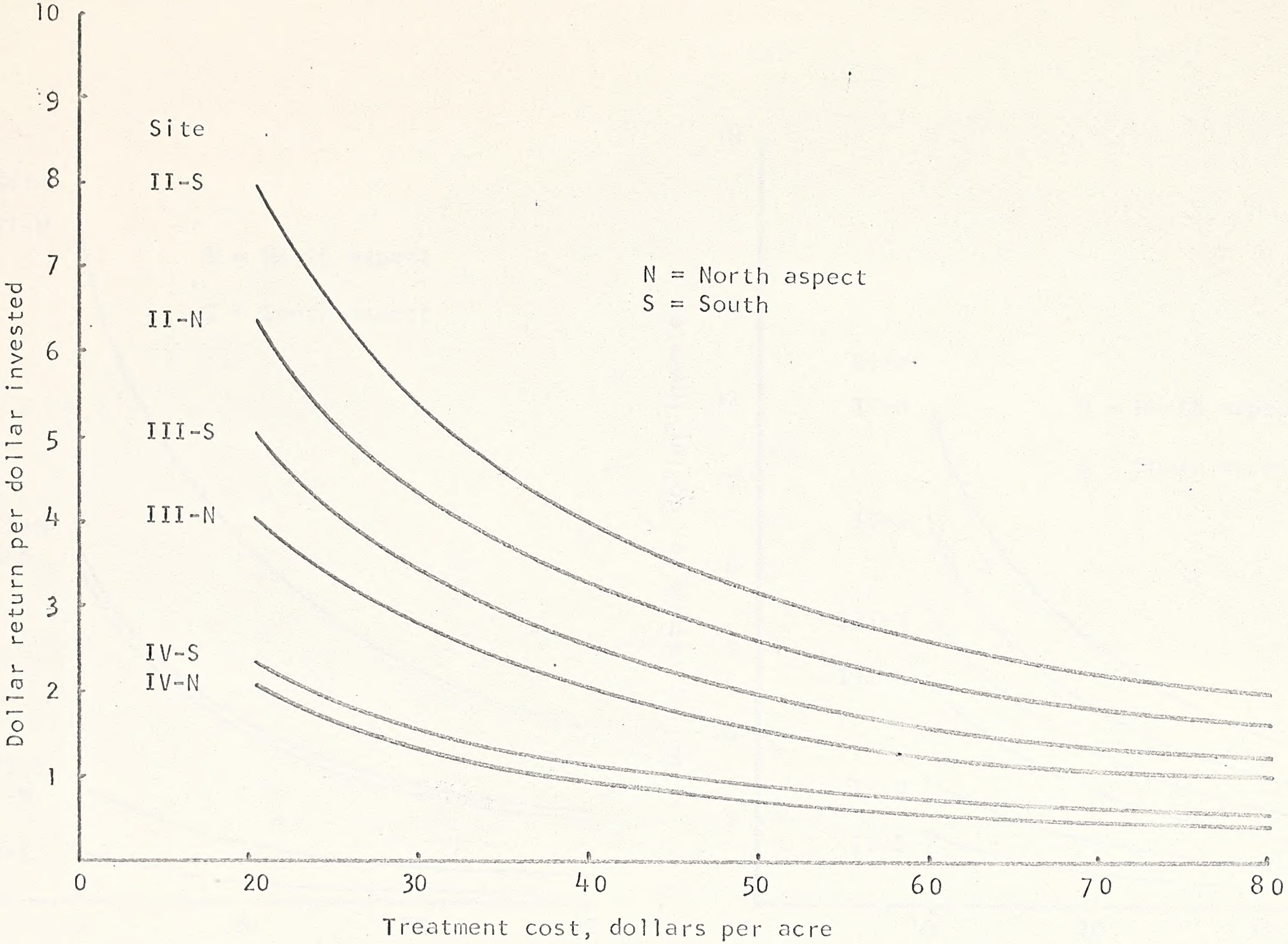

Figure 3. Dollar return per dollar invested. Planting east side land with good exposure mineral soil (70 percent or more)

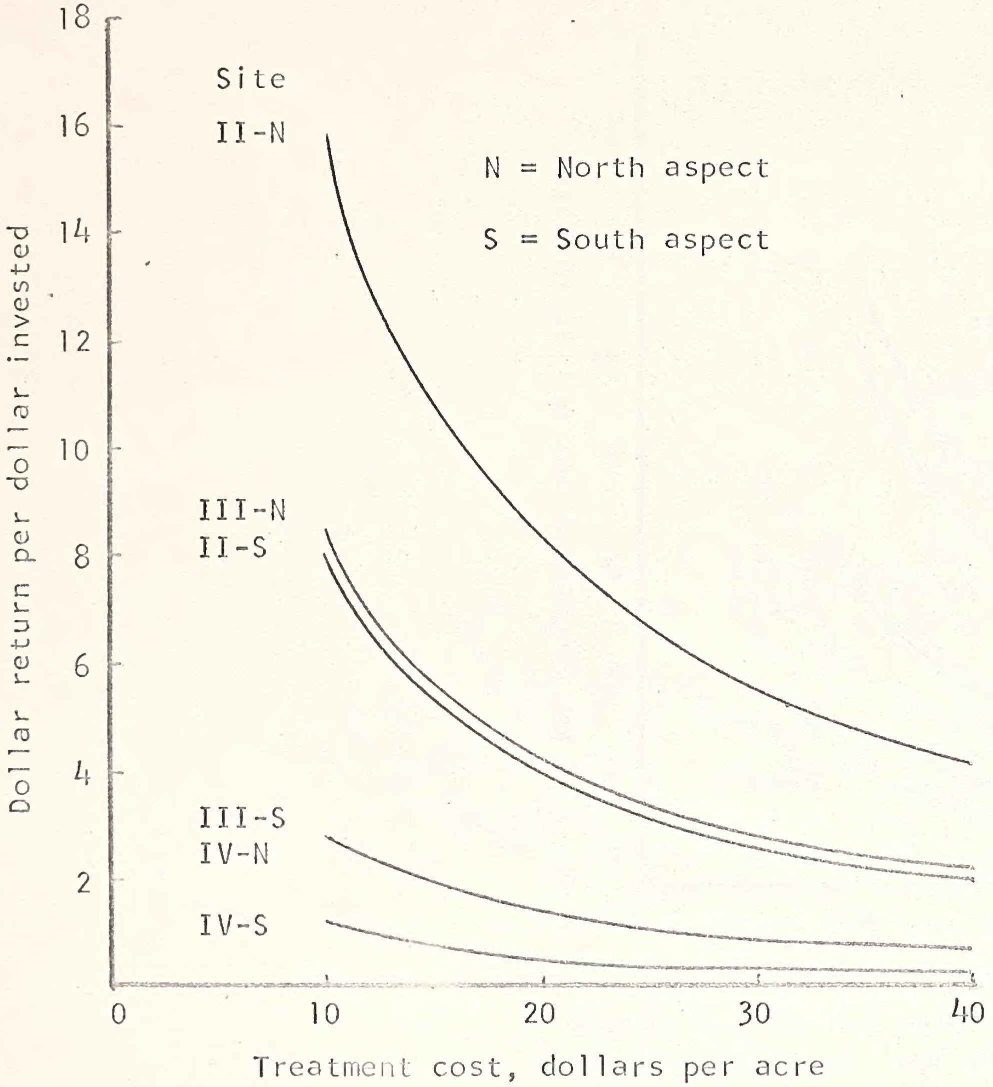

Figure 4. Dollar return per dollar invested. Aerial seeding eastside land with poor exposure mineral soil (0-29 percent).

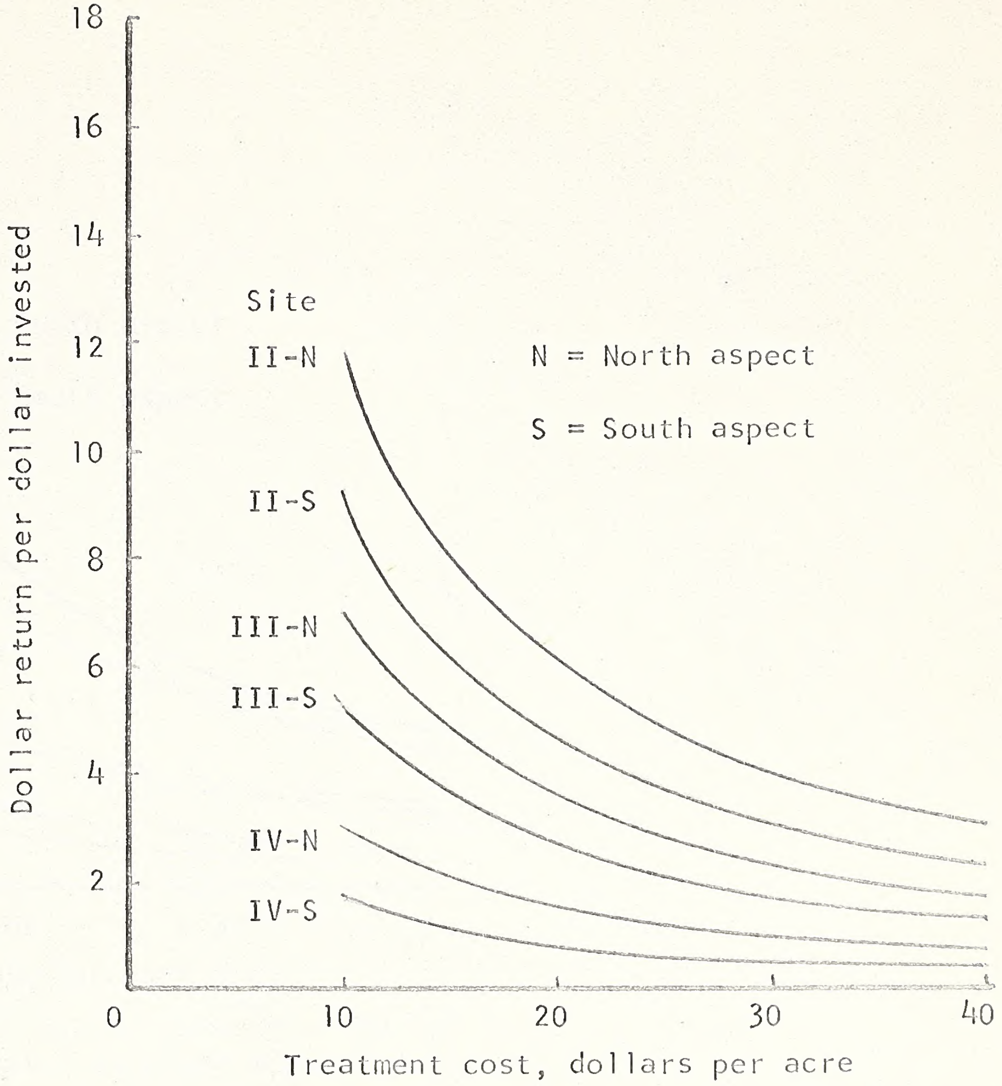

Figure 5. Dollar return per dollar invested. Aerial seeding eastside land with fair exposure mineral soil (30-69 percent).

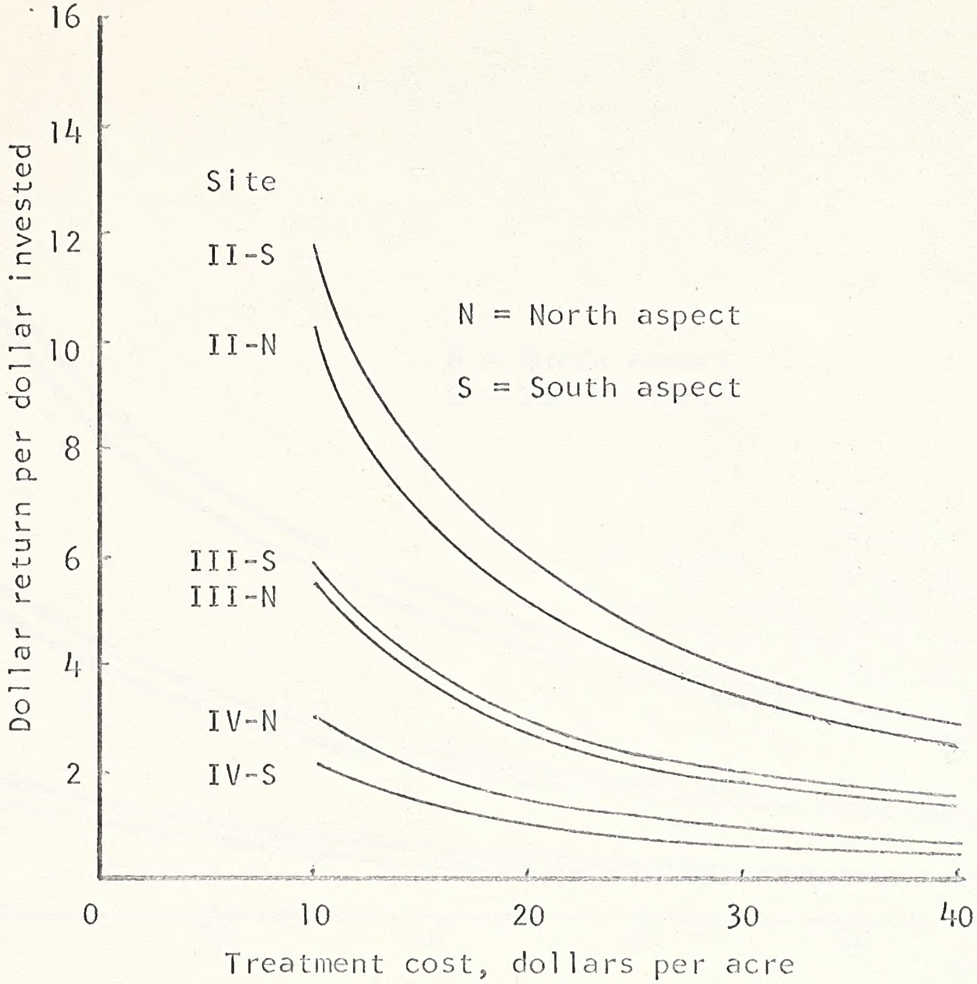

Figure 6. Dollar return per dollar invested. Aerial seeding eastside land with good exposure mineral soil (70 percent or more).

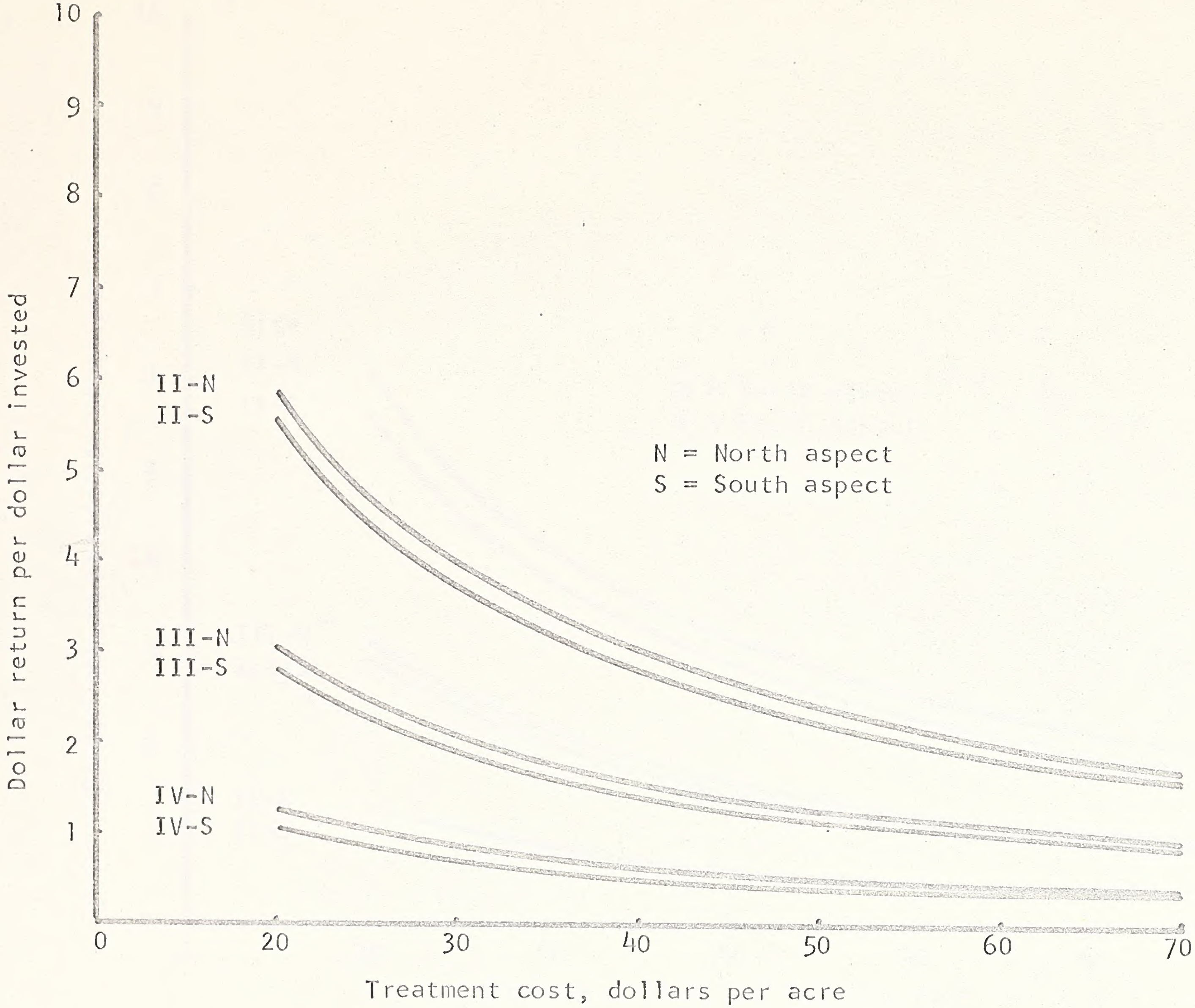

Figure 7. Dollar return per dollar invested. Interplanting east side land with poor exposure mineral soil (0-29 percent)

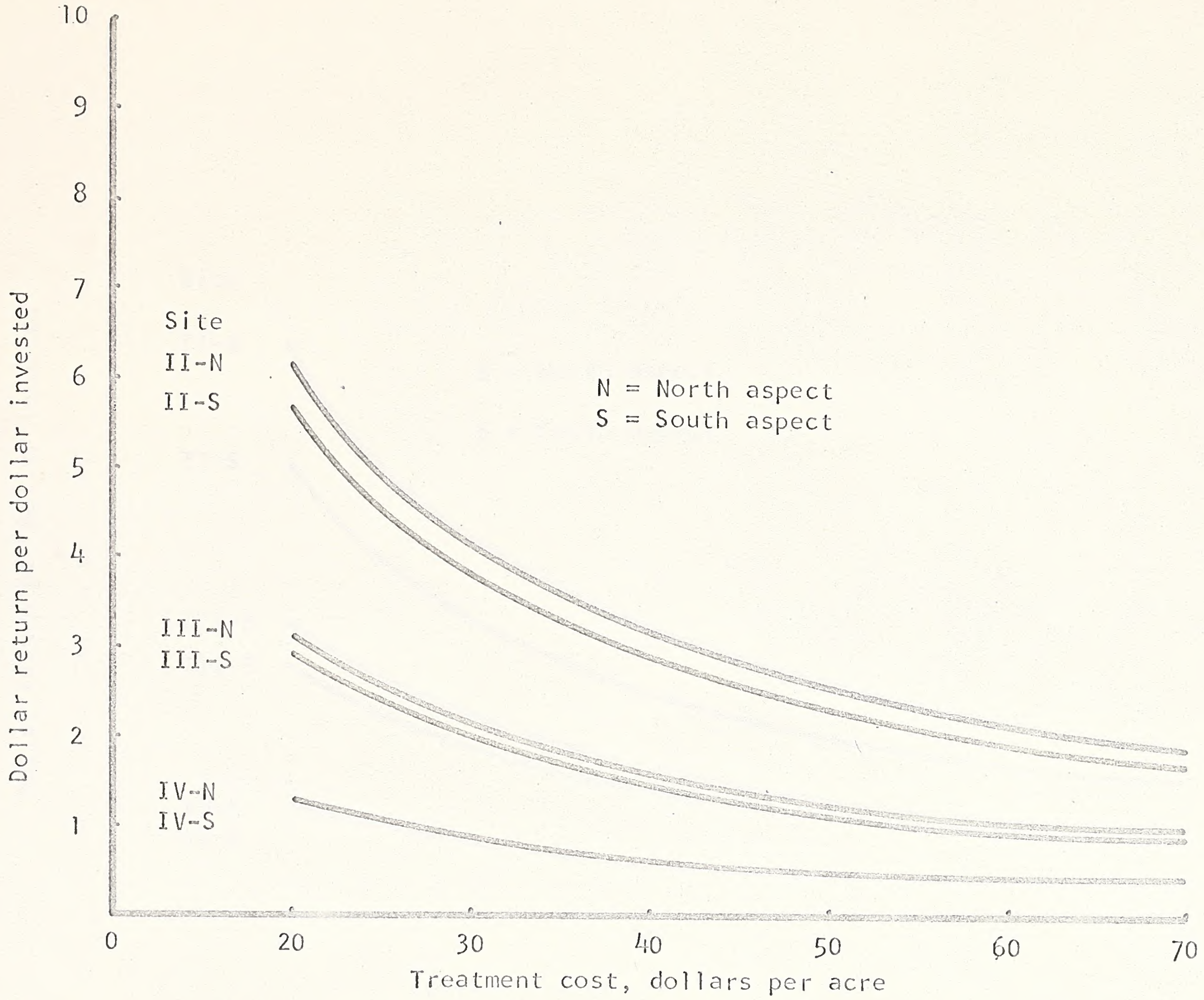

Figure 8. Dollar return per dollar invested. Interplanting east side land with fair exposure mineral soil (30-69 percent)

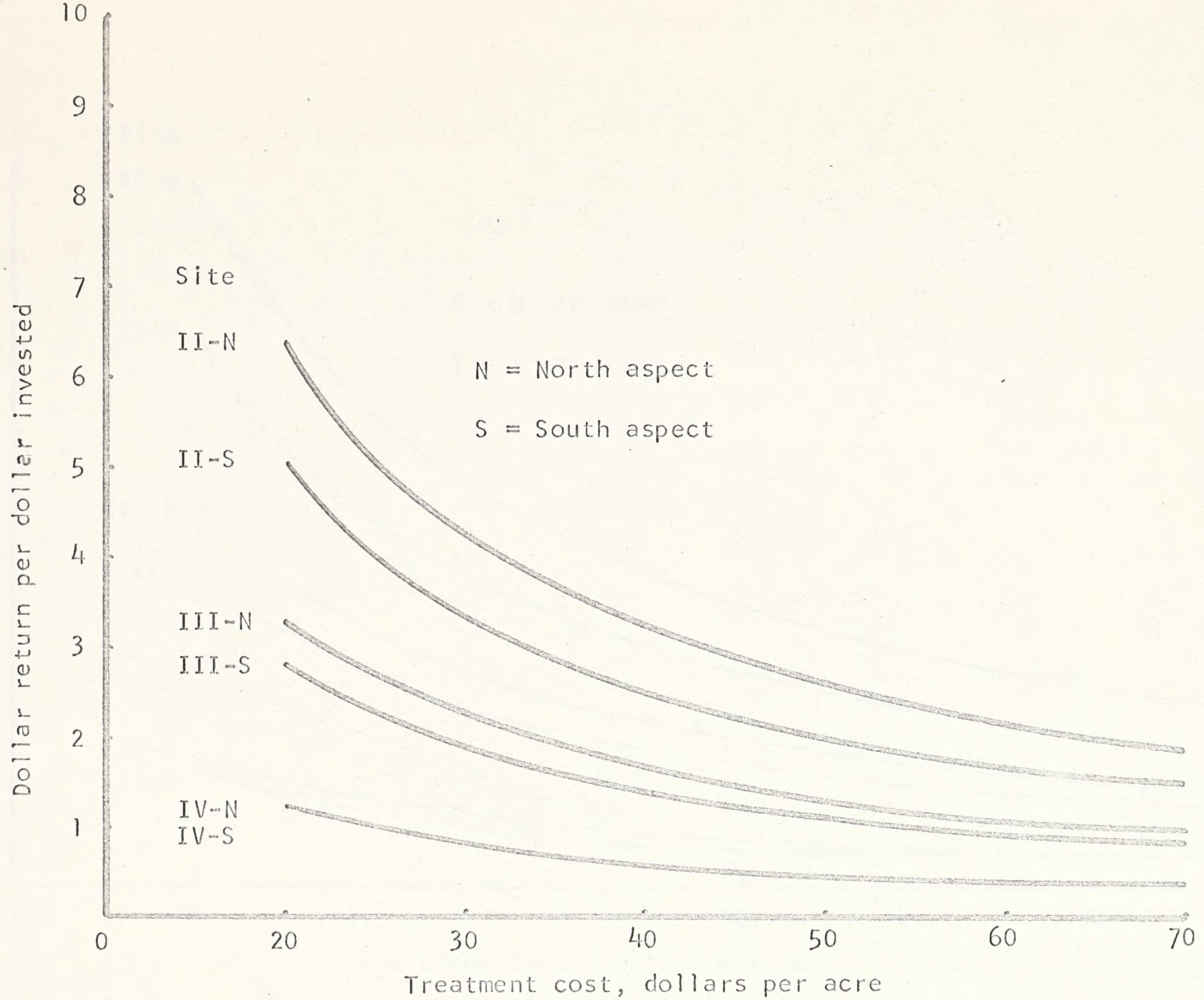

Figure 9. Dollar return per dollar invested. Interplanting east side land with good exposure mineral soil (70 percent or more)

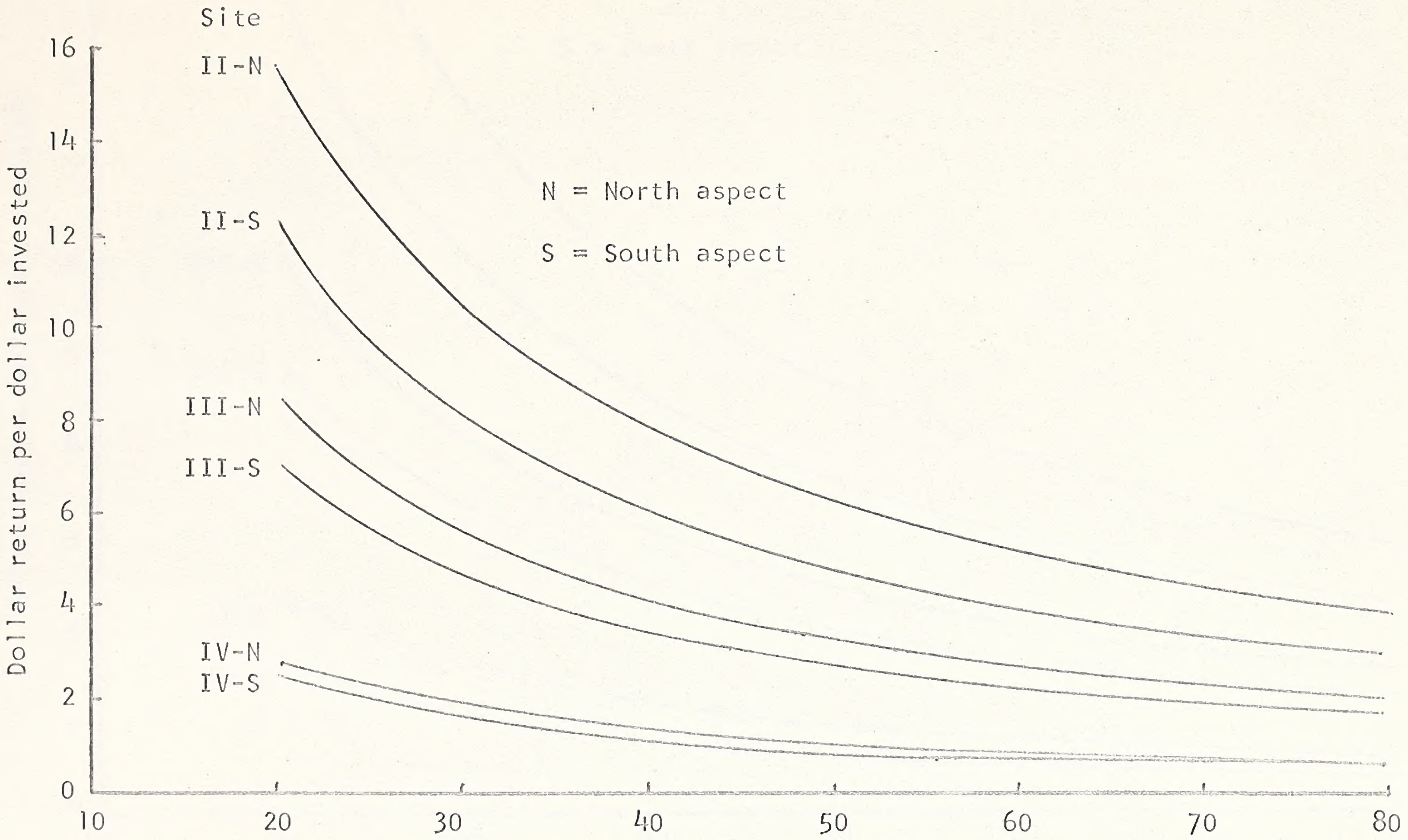

Figure 10. Dollar return per dollar invested. Planting eastside brush land (assumes good exposure mineral soil).

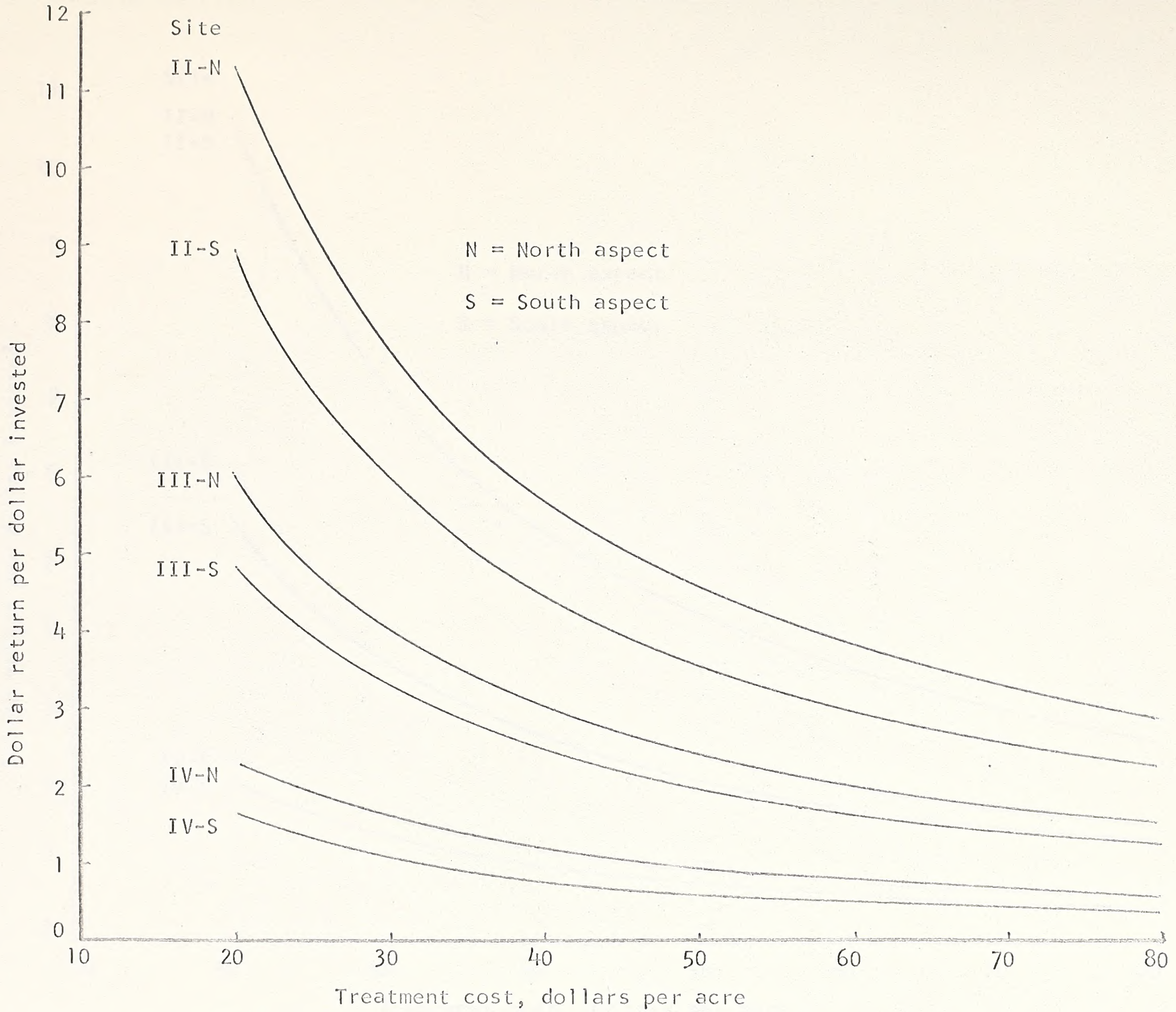

Figure 11. Dollar return per dollar invested. Planting westside land with poor exposure mineral soil (0-29 percent).

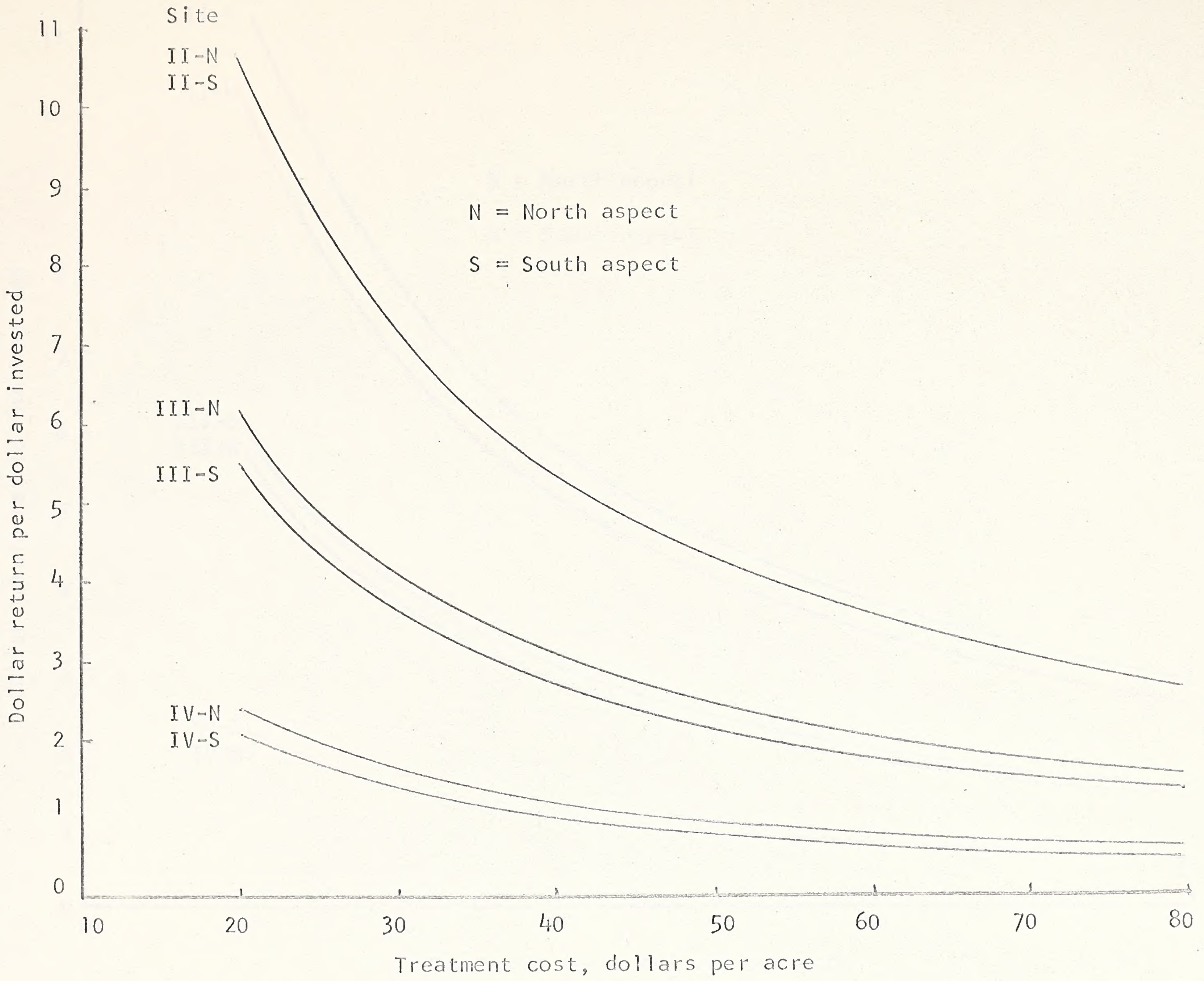

Figure 12. Dollar return per dollar invested. Planting westside land with fair exposure of mineral soil (30-69 percent).

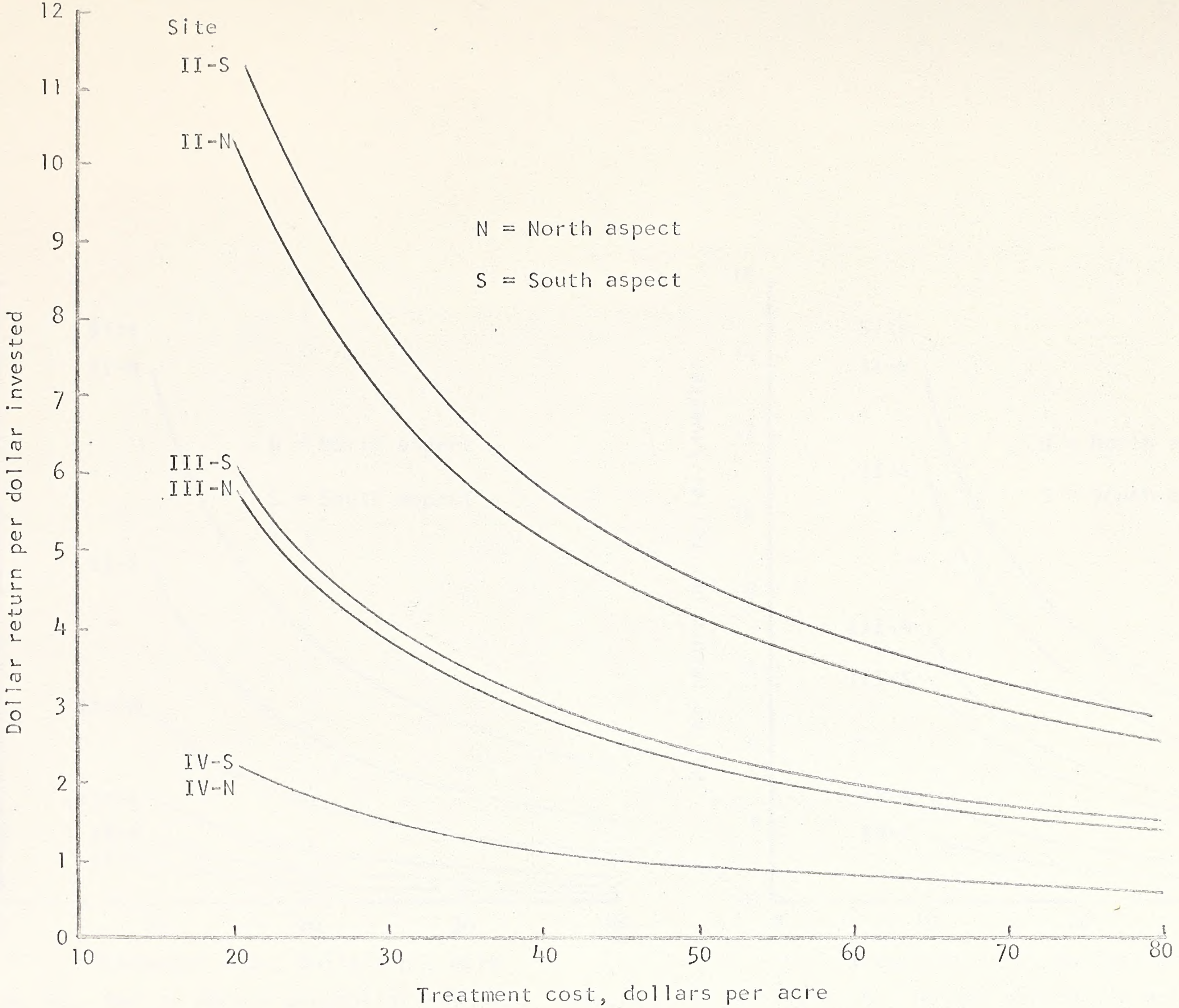

Figure 13. Dollar return per dollar invested. Planting westside land with good exposure mineral soil (70 percent or more).

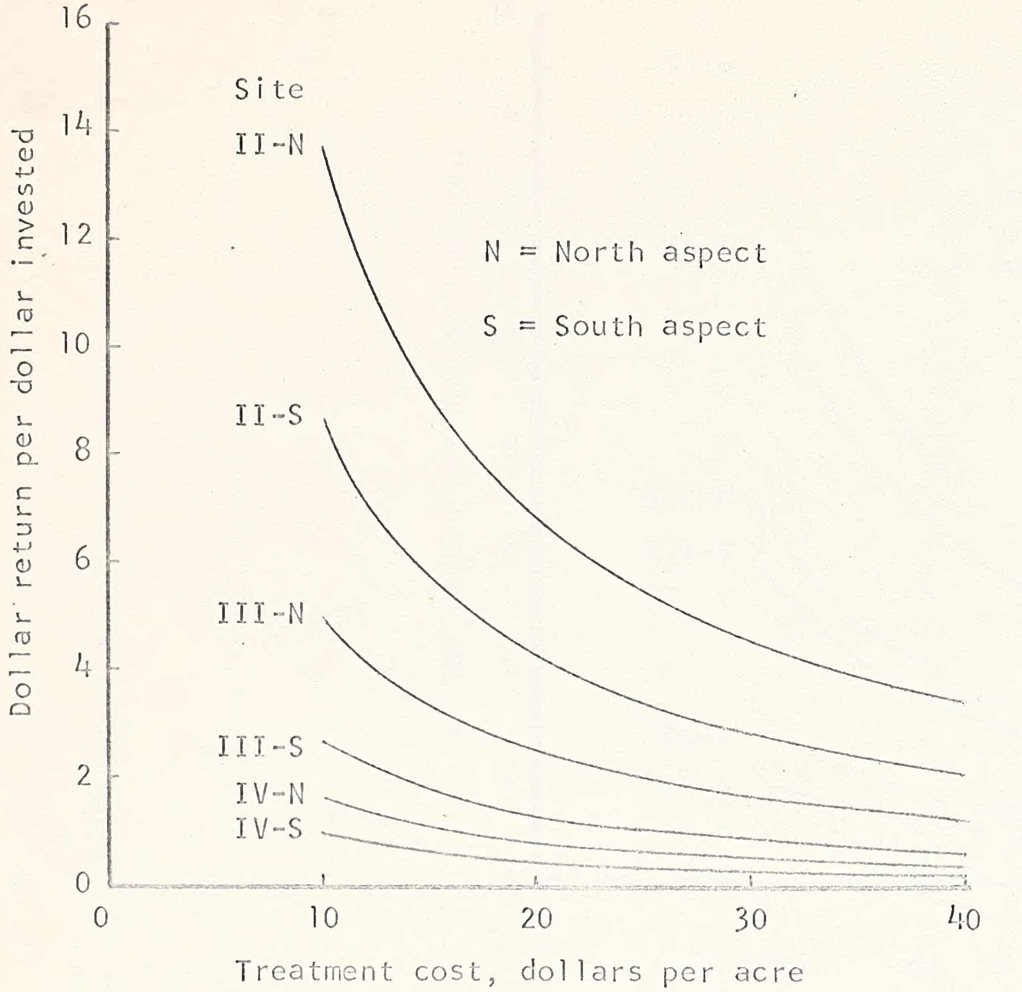

Figure 14. Dollar return per dollar invested. Seeding westside bare land with poor exposure mineral soil (0-29 percent).

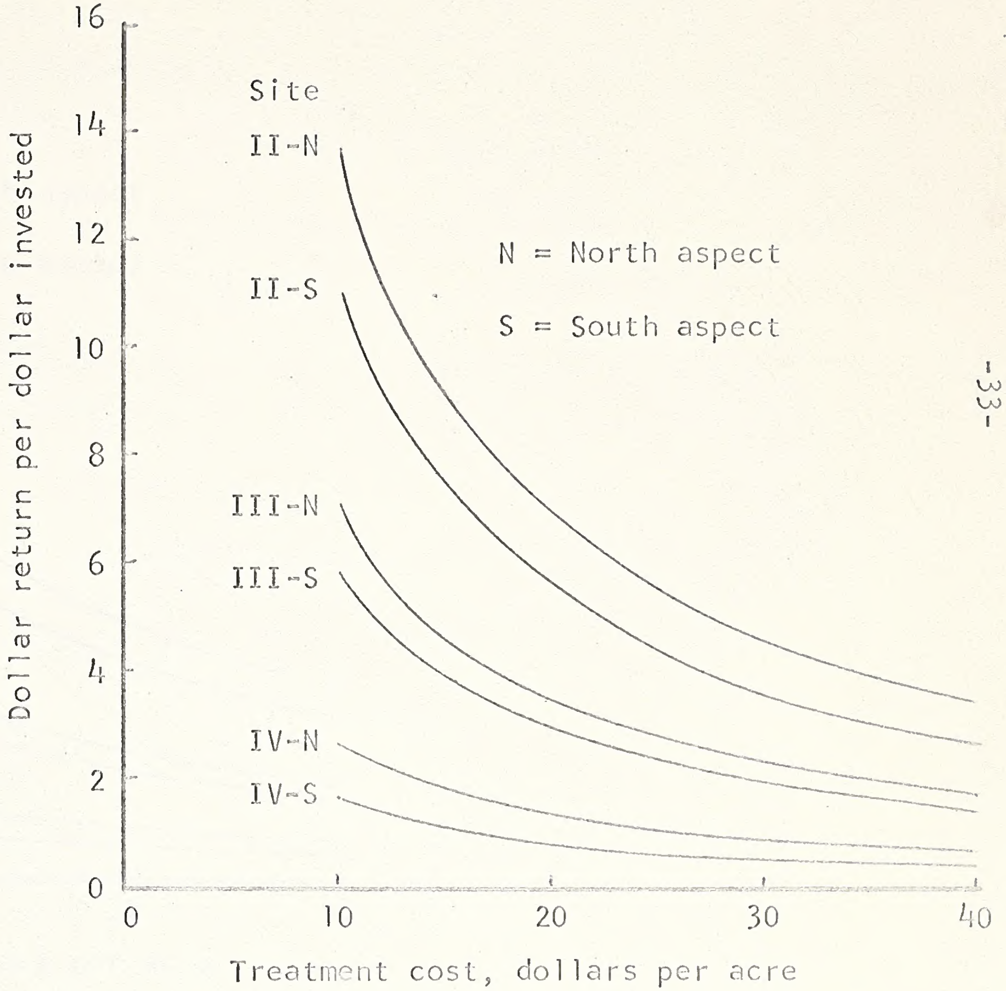

Figure 15. Dollar return per dollar invested. Seeding westside bare land with fair exposure mineral soil (30-69 percent).

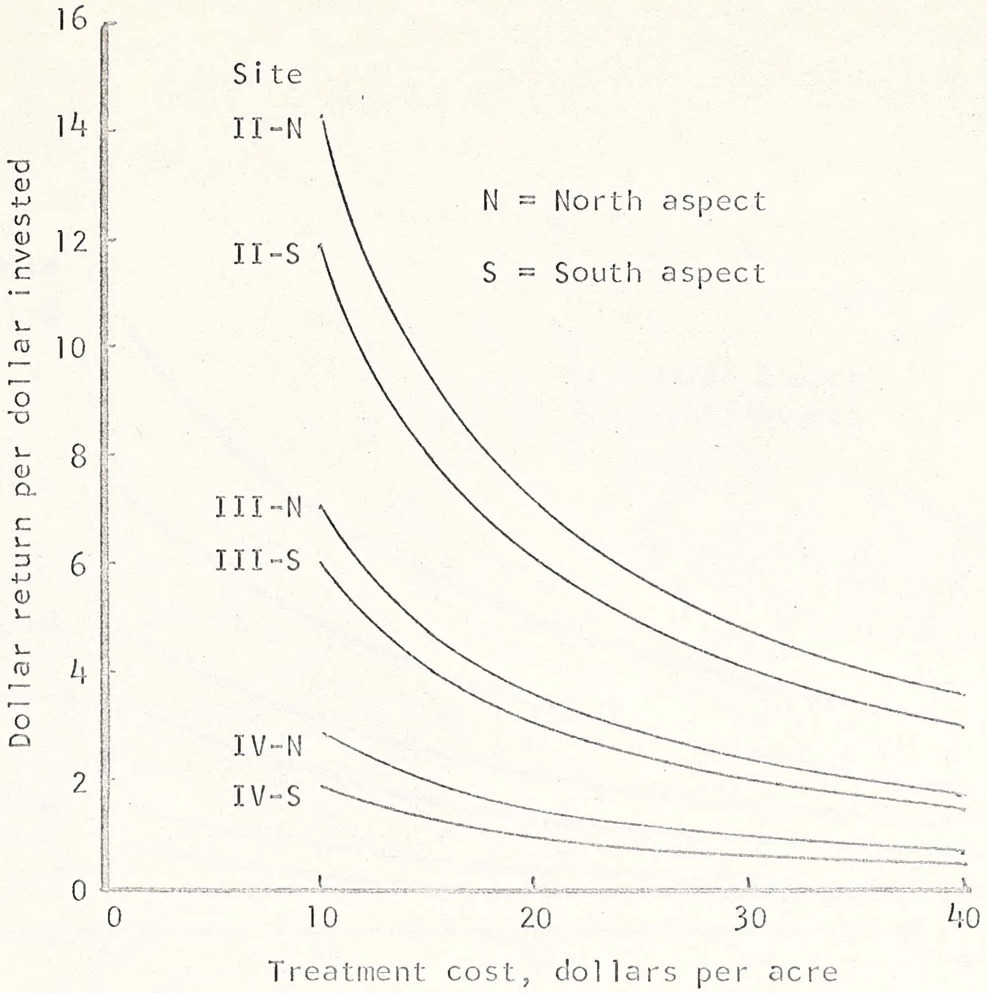

Figure 16. Dollar return per dollar invested. Aerial seeding westside land with good exposure mineral soil (70 percent or more).

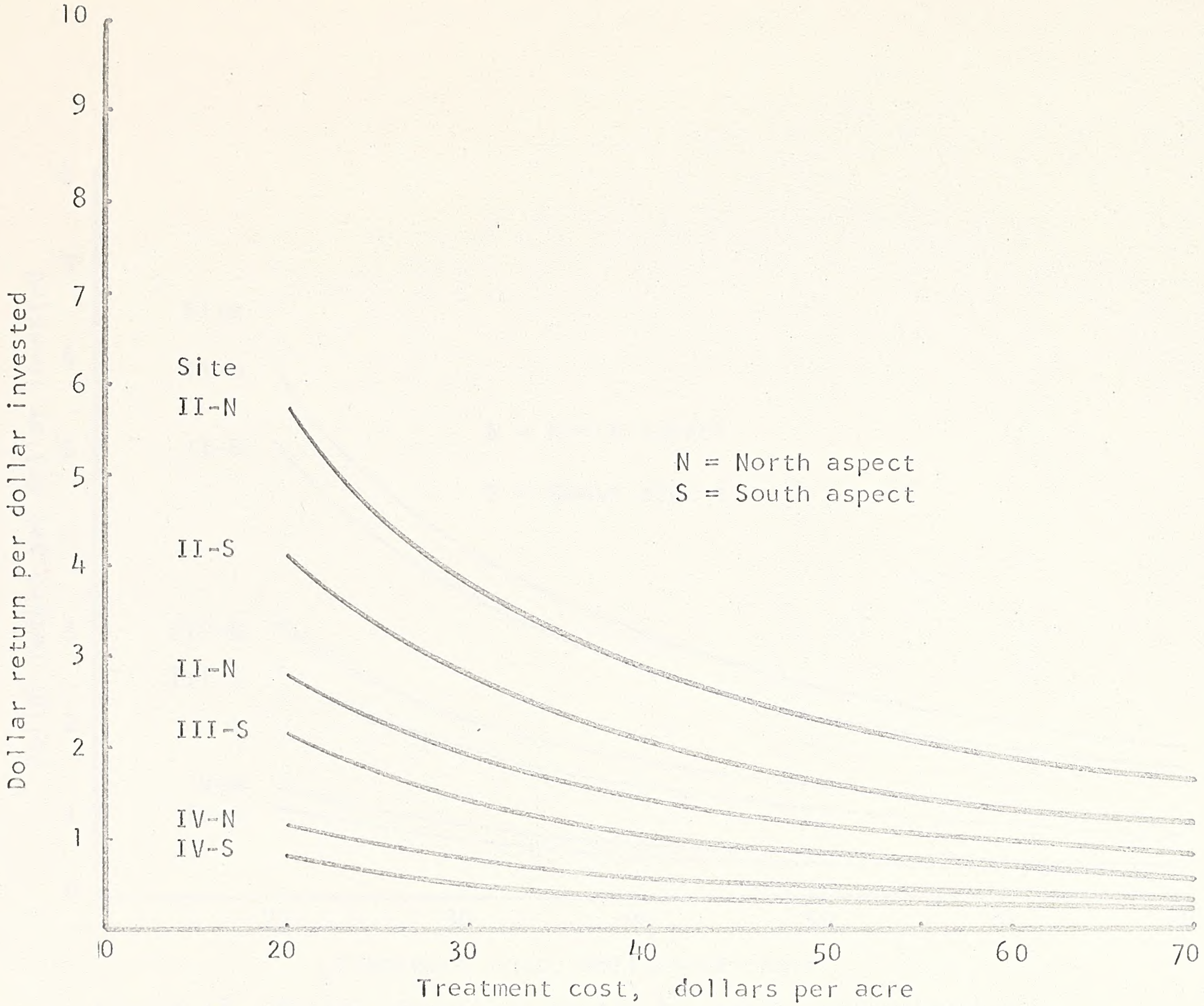

Figure 17. Dollar return per dollar invested. Interplanting west side land with poor mineral soil exposure (0-29 percent)

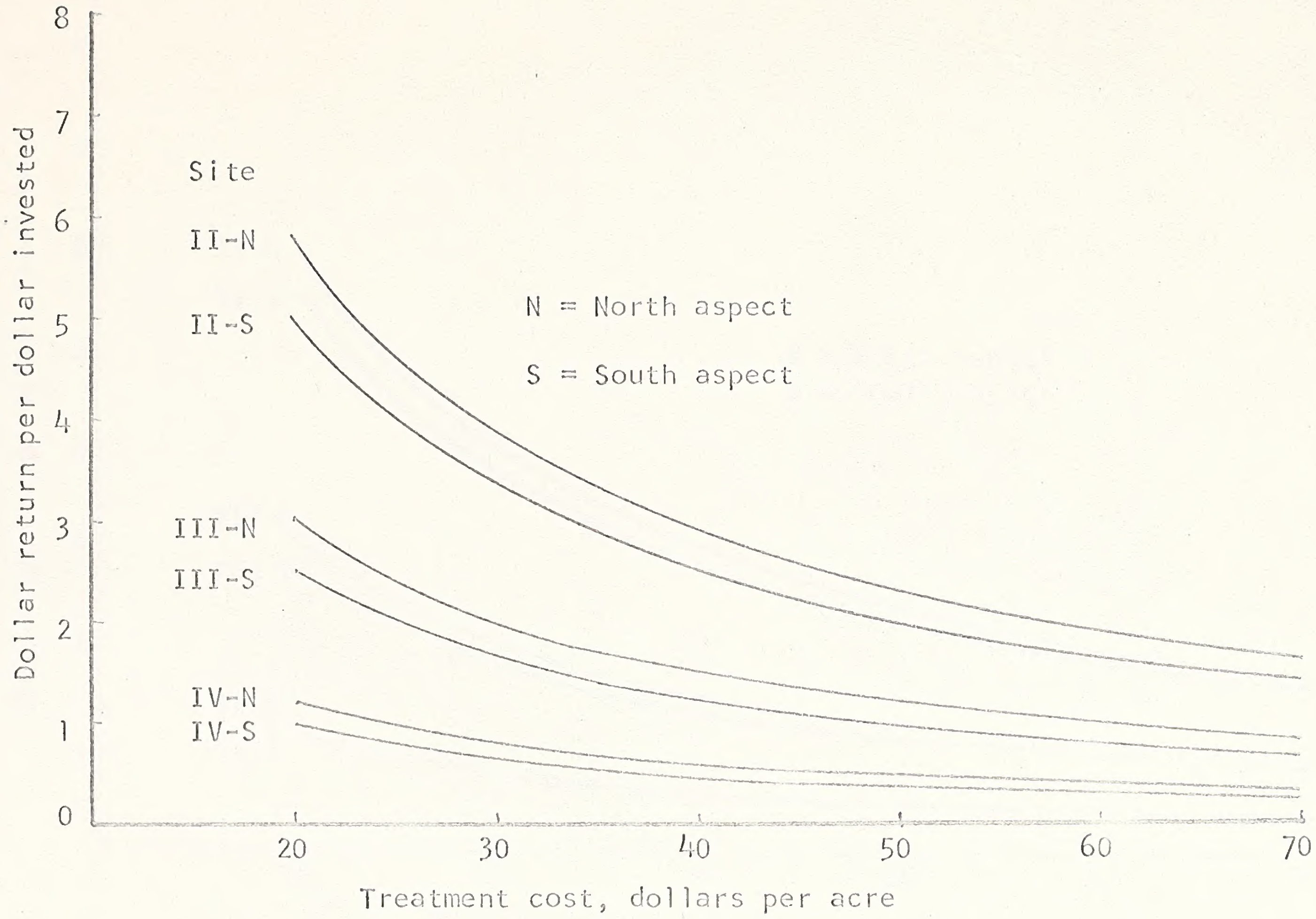

Figure 18. Dollar return per dollar invested. Interplanting westside land with fair exposure of mineral soil (30-69 percent).

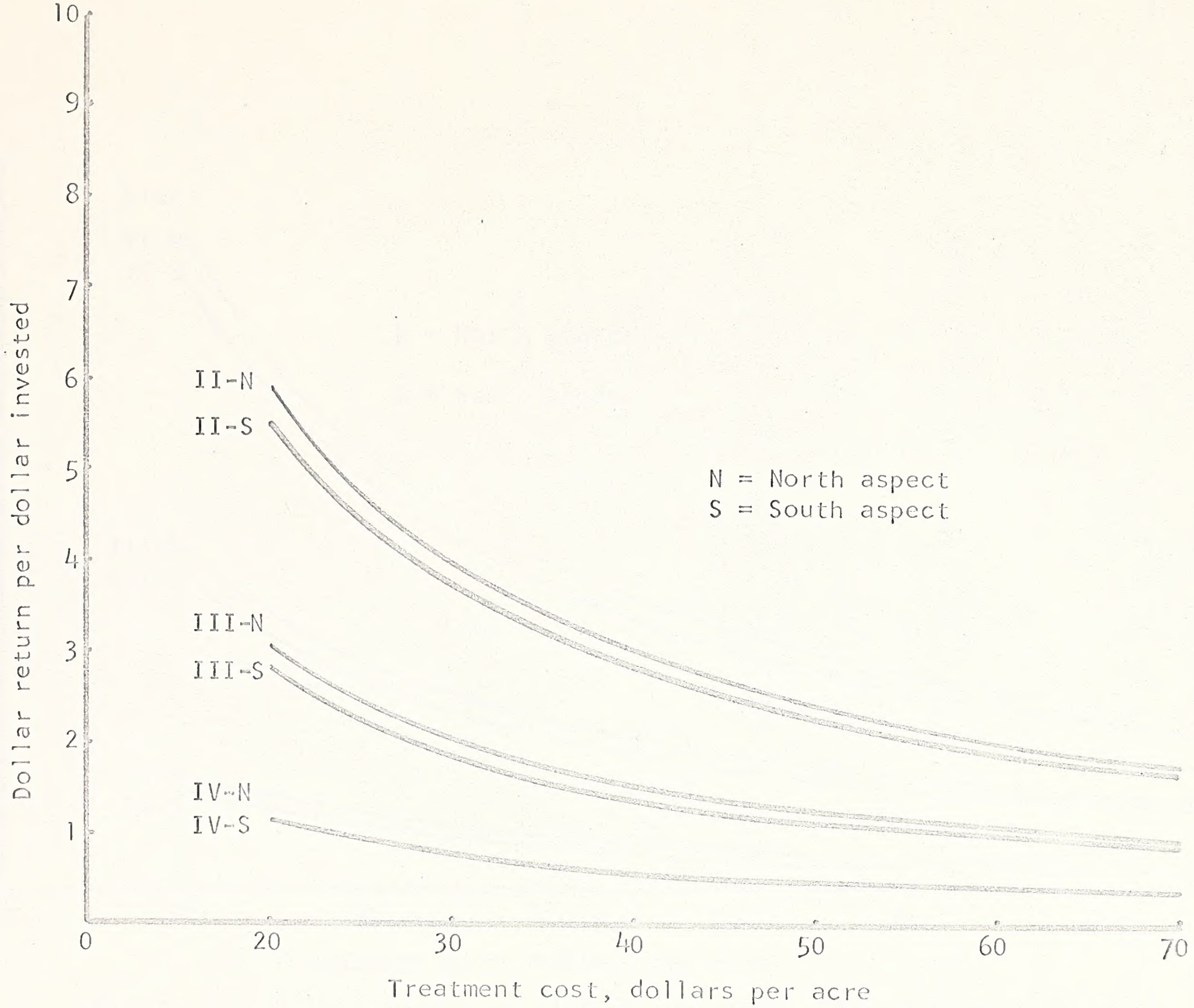

Figure 19. Dollar return per dollar invested: Interplanting west side land with good mineral soil exposure (70 percent or more)

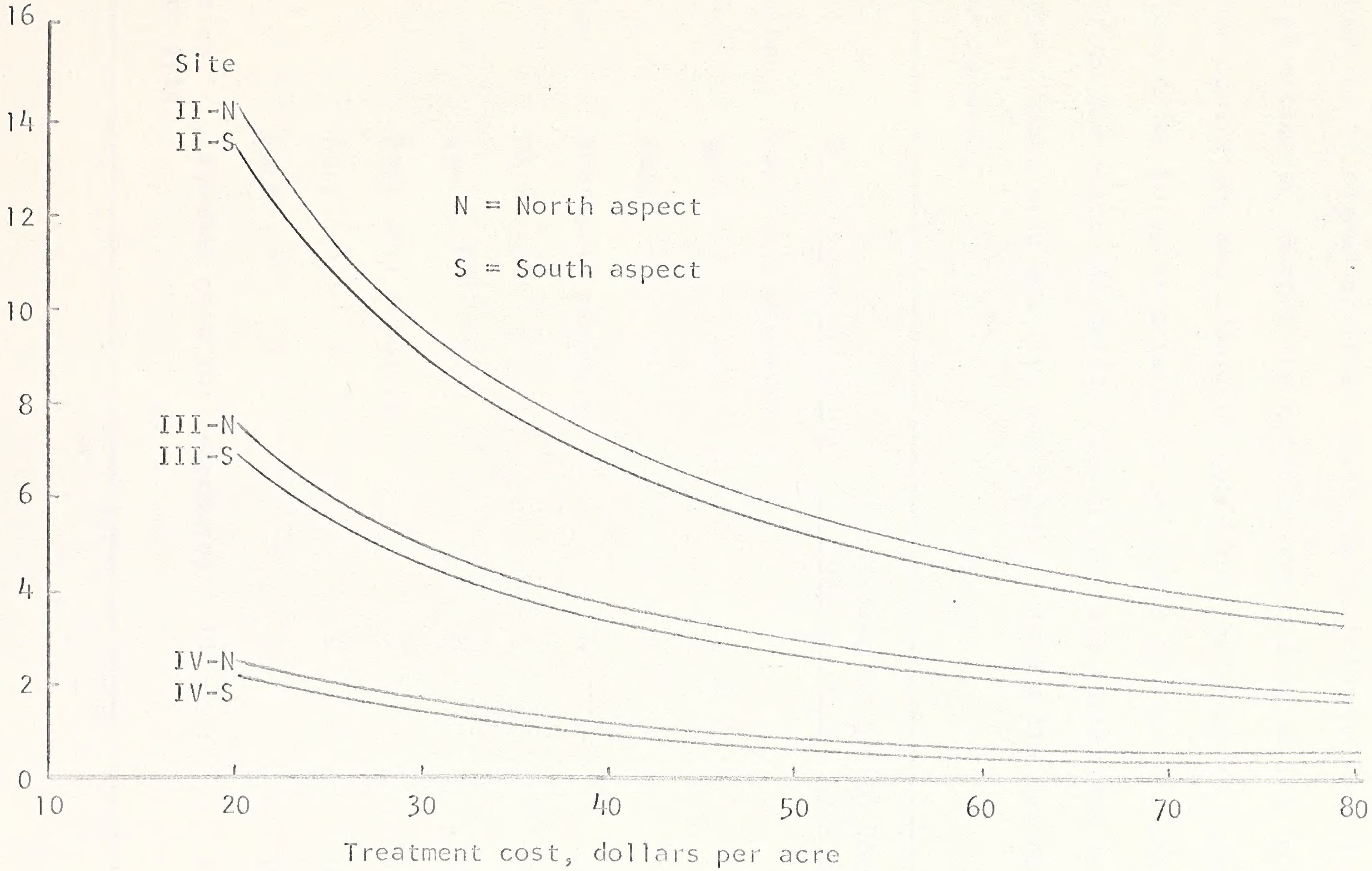

Figure 20. Dollar return per dollar invested. Planting westside brush land (assumes good exposure mineral soil).

and treatment. Then find the column corresponding to site quality and aspect. Record the estimated dollar return. If using the charts, first determine the treatment cost. Use Table 1 for this purpose; or if higher or lower costs are anticipated, prepare a revised estimate. Choose the chart corresponding to the location, seedbed condition, and treatment noted for the tract in step (1). See tabulation below as a guide to selecting the correct chart. Read from the chart the dollar return estimate corresponding to treatment cost, site quality, and aspect. Record the estimated dollar return.

Treatment	Site Characteristics	In Cascade Range Use chart	In Coast Range Use chart
First plantings on bare land	Poor soil exposure	1	11
	Fair " "	2	12
	Good " "	3	13
First seedings on bare land	Poor soil exposure	4	14
	Fair " "	5	15
	Good " "	6	16
Interplantings	Poor soil exposure	7	17
	Fair " "	8	18
	Good " "	9	19
First plantings on brushland with site preparation	(assumes good soil exposure)	10	20

3. For bare land situations where a planting or seeding option is to be considered, use the table or charts to determine the dollar-return for both methods. Record the highest dollar return and identify the tract as a seeding or planting chance.
4. List the areas to be considered for treatment. Show the areas with the highest dollar return at the top of the list. In separate columns show the estimated acreage in each and the estimated total cost of performing the indicated work.
5. Select for treatment those tracts which are at the top of the list, moving down until the total cost of the highest rated tracts is equal to available funds.

The dollar return estimates given in this report are intended to serve as guides rather than as a substitute for the exercise of informed professional judgement. The method of analysis was designed to consider major factors which influence returns to expenditures to establish regeneration artificially. By combining these factors into a single index of investment desirability, guides are provided which should be helpful in the task of establishing work priorities. However, apart from imperfections in data and in underlying assumptions, some factors have been ignored. One limitation is that no consideration was given to possible economies which might be realized by grouping tracts of land in a specific area for concurrent treatment under a single work contract. Thus one tract of land might receive priority over another, even though it is given a lower rating of the priority scale, because it is efficient to do all the work in a given area rather than returning at some later date to treat an isolated tract. Another limitation is that the dollar-return criteria are intended for use when the budget is the only factor which limits the amount

or kind of reforestation work which can be accomplished. But manpower, ssedlings, and seed are also required. If availability of these resources also limit the work which can be done, then a ranking of projects according to dollar return may produce a less efficiently designed reforestation program than some alternative criteria or procedures such as linear programming.[4]

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[4] See Teeguarden, Dennis E. and H. Von Sperber 1968. Scheduling Douglas-fir reforestation investments: a comparison of methods. Forest Science 14(4): 354-367.